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V-Tanks Contents Remediation Mechanical Design

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This EDF presents design description and calculations for the mechanical design of the V-tanks contents removal system.
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INTRODUCTION

This project will remove the contents from four buried waste tanks, remove the tanks themselves and associated piping, and remove contaminated soils surrounding the tanks. The tanks are located at Test Area North (TAN) on the Idaho National Environmental and Engineering Laboratory (INEEL). The tanks included are V-1, V-2, V-3, and V-9.

The project will transfer sludge and liquid from the four buried tanks to three new consolidation tanks located in a relocated weather enclosure north of TAN-666. The four buried tanks will then be removed from the ground and transported to the Idaho CERCLA Disposal Facility (ICDF) located near the Idaho Nuclear Technologies and Engineering Complex (INTEC). The contaminated soils surrounding the tanks will be excavated and stockpiled for future transport to the ICDF. The liquid and sludge will be treated and transported to ICDF.

Tank V-1 is a 10,000-gallon stainless steel storage tank. This tank contains approximately 520 gallons of sludge under approximately 1,164 gallons of liquid. The tank is buried with approximately 10 ft of cover.

Tank V-2 is a 10,000-gallon stainless steel storage tank. This tank contains approximately 458 gallons of sludge under approximately 1,138 gallons of liquid. The tank is buried with approximately 10 ft of cover.

Tank V-3 is a 10,000-gallon stainless steel storage tank. This tank contains approximately 652 gallons of sludge under approximately 7,660 gallons of liquid. The tank is buried with approximately 10 ft of cover.

Tank V-9 is a 400-gallon stainless steel storage tank. This tank contains approximately 250 gallons of sludge under approximately 70 gallons of liquid.

PURPOSE

This EDF contains the engineering design information including process description, vendor literature, and design calculations for the mechanical (excluding tank ventilation and off-gas) portions of the design. The purpose for this EDF is to present the design for information and clarification of the design package, and to be a reference for beginning the system operating procedures.

CONTENTS REMOVAL SYSTEM

Contents Removal Sequence

The following sequence contains a listing of events for contents removal of V-1, V-2, V-3, and V-9. The sequence assumes that excavation has occurred, and V-1, V-2, V-3 & V-9 tank nozzle flanges are exposed.

Note: The following steps need not be performed in sequence, and may be performed out of the order listed in accordance with operations and project direction.

1. **Remove Supernate from V-3**: Pump supernate liquid (approximately 6,000 gallons) from V-3 to a supernate storage tank.

2. **Remove Contents and Wash V-9**: Pump sludge from V-9, using V-3 supernate as a sludge liquefier and spray wash utilizing spray nozzles or a high pressure washer. Use V-3 supernate to

wash walls of V-9 utilizing spray nozzles or a high pressure washer. Use clean water (if needed) to rinse V-9.

3. **Circulate Contents of V-1, V-2, & V-3**: Circulate the contents of V-1, V-2, & V-3 (order not critical) with high volume circulation pump system to suspend sludge as much as possible.

4. **Remove Contents From V-1, V-2, & V-3**: Remove the contents including the supernate/sludge mixture from V-1, V-2, and V-3 (order not critical) with sump suction system.

5. **Remove Remaining Supernate and sludge from V-1, V-2, & V-3**: Pump remaining water and sludge in V-1, V-2, and V-3 from the sump suction line or the moveable suction. Circulate as necessary through wash wands or high pressure washer.

6. **Wash Tanks V-1, V-2, & V-3 with Clean Supernate/Clean Water**: Use V-3 supernate to wash walls of V-1, V-2, & V-3 through spray wands or high pressure washer. Use clean water (if needed) to rinse V-1, V-2, & V-3.

Contents Removal Pump Design

Requirements:

1. Pump liquid, sludge, slurry, and solids up to ¾" diameter.

2. Pump 6000 gallons of water (V-3 supernate) in less than one shift (8 hours working time).

   Q = V/t = {(6,000 gal) / (8 hr)}(1 hr / 60 min) = 12.5 gpm (minimum for water) ➔ Use 20 gpm

3. Pump 1,500 gallons of sludge/liquid mixture (V-1, V-2, & V-3 each) in one shift (8 hours).

   Q = V/t = {1,500 gal) / (8 hr)}(1 hr / 60 min) = 3.1 gpm (minimum for sludge) ➔ Water limits

4. Pressure as required to deliver desired flows.

   From Piping System Design calculations below, pipe is 1 ½" diameter.

   From Piping System Design calculations below, supernate pumping requirements are 20 gpm at 23 psig.

   Assume sludge is mixed with water for pumping. Assume pressure losses for sludge are 10 times water losses. From Piping System Design calculations below, sludge/supernate mixture pumping requirements are 20 gpm at 54 psig. Use pump capable of delivering 20 gpm at 100 psig.

5. Vertical suction lift of 15 ft. minimum.

6. Reversible to back flush clogged suction tube (or valve arrangement for back flush from supernate system).

7. Variable speed or capable of being throttled to vary flow.

The following pump is available to the project: Watson Marlow Model SPX-40 High-Pressure Hose Pump. This pump is a parastaltic type pump with a 5 hp variable speed reversible drive, capable of delivering water in excess of 20 gpm at 100 psig under continuous operation. ➔ This pump is acceptable.

<u>Contents Removal Piping System Design</u>

1. Generally a velocity between 5 and 10 fps is desired to to keep solids (sand and dirt) mixed and flowing with the liquids. However, during mock-up testing it was determined that this velocity created too high of a pressure loss through the required piping distances. Velocities of 2 to 3 fps were found to keep the solids mixed and flowing with the liquids with no major settling or other problems.

   At 20 gpm, choose pipe size to obtain between 2 fps and 5 fps velocity.

   V = 1.91 ft/sec for 2" pipe ➔ Too slow.
   V = 3.16 ft/sec for 1 ½" pipe ➔ Acceptable.
   V = 7.43 ft/sec for 1" pipe ➔ Pressure loss too high.

   Choose 1 ½" pipe with velocity of 3.16 ft/sec

2. Working pressure up to 100 psig.

3. Abrasion resistant for sludge and slurry applications.

4. Resistant to radiation and chemicals (see Sam Ashworth EDF, this project).

5. Calculate Pressure Drop:

   Supernate (water) Pressure Drop:

   Q = 20 gpm

   Velocity = 3.16 ft/sec

   f = friction factor = 0.0205 (Crane TP-410 for complete Turbulence in 1 ½" Drawn Tubing)

   Pump pressure will include suction side and discharge side losses as follows:

   Total Head = Static Head + Dynamic (Velocity) Head + Friction Head + Minor Losses

   Static Head = (Highest piping on Consol. Tank) – (V-3 Tank Bottom - 2 ft.)
   = (4804 ft) – (4762 ft - 2 ft)
   = 44 ft

   Dynamic Head = $v^2/2g$
   = $(3.16 \text{ ft/sec})^2 / [(2)(32.2 \text{ ft/sec}^2)]$
   = 0.16 ft

   Friction Head = f (L/D) ($v^2/2g$)
   = (0.0205) [(300 ft)/(1.5/12 ft)] [0.16 ft]
   = 7.9 ft

   Minor Losses = Negligible for HDPE Pipe with minimal valves and fittings

Total Head $= 44\text{ ft} + 0.16\text{ ft} + 7.9\text{ ft} = 52\text{ ft}$
$= (52\text{ ft})(1\text{ psi} / 2.3\text{ ft}) = 23\text{ psi}$

➔ **Supernate pumping requirements are 20 gpm at 23 psig.**

Sludge/Supernate Pressure Drop:

Assume that the sludge/supernate mixture is 10 times more difficult to pump (friction factor 10 times that of water). This assumption was validated during the mock-up testing. The new pumping requirements for the sludge/supernate mixture is as follows:

Velocity = 3.16 ft/sec

f = friction factor = (0.0205)(10) = 0.205

Pump pressure will include suction side and discharge side losses as follows:

Total Head = Static Head + Dynamic (Velocity) Head + Friction Head + Minor Losses

Static Head = (Highest piping on Consol. Tank) – (V-3 Tank Bottom - 2 ft.)
= (4804 ft) – (4762 ft - 2 ft)
= 44 ft

Dynamic Head $= v^2/2g$
$= (3.16\text{ ft/sec})^2 / [(2)(32.2\text{ ft/sec}^2)]$
= 0.16 ft

Friction Head $= f\,(L/D)\,(v^2/2g)$
$= (0.205)\,[(300\text{ ft})/(1.5/12\text{ ft})]\,[0.16\text{ ft}]$
= 78.7 ft

Minor Losses = Negligible for HDPE Pipe with minimal valves and fittings

Total Head $= 44\text{ ft} + 0.16\text{ ft} + 78.7\text{ ft} = 123\text{ ft}$
$= (123\text{ ft})(1\text{ psi} / 2.3\text{ ft}) = 54\text{ psi}$

➔ **Sludge/Supernate pumping requirements are 20 gpm at 54 psig.**

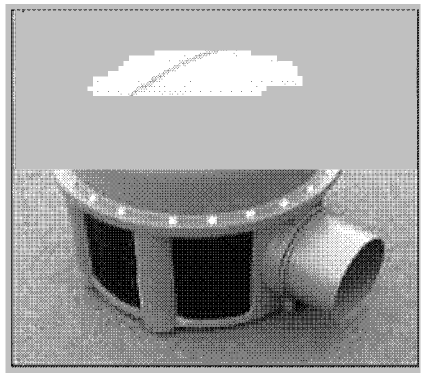
V-3 Supernate Suction Design

This system will be used to pump approximately 6,000 gallons of supernate from V-3 prior to removing contents from any other tank.

Pump suction will be screened to prevent debris from entering this system. The suction will be a floating suction to allow pumping the clean supernate with minimal disturbance of the underlying sludge.

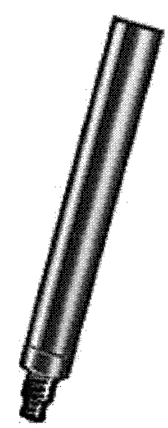
Use Suction/Discharge flexible hose capable of full vacuum and up to 200 psig pressures, 1-½" hose size

Use Megator Corporation Dolphin Floating Suction Strainer, 1-1/2" Hose Size.



TYPE	HOSE SIZE	STRAINER DIAMETER	STRAINER HEIGHT	MAX. CAPACITY
1½"	1½"	5¾"	7⅜"	37 US gpm
	38mm	146mm	162mm	140 lt/min

V-1, V-2, & V-3 Moveable Suction



Sludge from the bottom of V-1, V-2, & V-3 will be removed under the existing clear water (approximately 1,000 gallons in each tank) with the moveable suction line, acting much like a vacuum cleaner wand. The moveable suction will be composed of 3 major components: 1) Manual Extension Rod, 2) Suction Nozzle, and 3) Suction Hose.

The manual extension rod will be a 1 3/4" diameter aluminum concrete float extension handle, with four 6 ft. sections. The extension rod will reach to both ends of the tanks through the existing 20" diameter manholes on each tank. The rod will be manipulated manually from above the tanks. Temporary shielding for the operators may be required, and will be evaluated by radcon personnel during operations.

The suction nozzle is designed to simply provide a suction wand action at the end of the suction wand. The suction inlet will be 1 ½" pipe flattened on the end to form a 1" (max.) opening to screening action and also provide an increased flow velocity. The suction pipe will be connected to the extension handle. The suction pipe will contain a 45 degree elbow to allow for the suction pipe to be placed inside the tank sumps.

The suction hose will be routed through the existing 3" diameter vent nozzle on each tank. The hose will be lowered into the tanks (above the water and sludge) to a point where a hook on an extension rod can be used from the manhole to bring the hose end back up to the manhole. The hose will then be connected to the suction nozzle and manual extension rod, and the assembly will be lowered into the sludge.

V-1, V-2, & V-3 Sump Suction

The sump suction will be located in the existing tank sump. A suction tube (4" schedule 40 stainless steel pipe) currently extends from the existing suction nozzle to within 6" of the bottom of the sump. A new 3" suction line will be inserted into the existing suction tube and will extend below the suction tube into the sump. This suction line will serve as the suction line for both the recirculation pump and the contents removal pump. The contents removal pump will take suction from the 3" sump line upstream of the recirculation pump.

V-9 Suction

The suction line from V-9 will be a 1 ½" pipe inserted into the existing 6" vent line in the top of V-9. The pipe will be aluminum. The suction line elevation will be adjustable, with a pipe riser clamp attached to the suction pipe to maintain the desired height. The suction end of the pipe will be flattened to a maximum opening of 1" to prevent larger solids from entering the pipe. The suction line will be attached to a suction hose leading to the contents removal pump system.

Suction Manifold

The suction hoses from each of the above suction locations will be connected to a suction manifold consisting of the valves and piping necessary to allow for operation of any of the suction sources from any of the tanks. Suction piping will be single wall 1" diameter DriscoPlex 3408 series HDPE piping for abrasion resistance. The piping will be SDR-9.0 to help withstand vacuum pressures. Manifold valves will be ¼ turn ball valves.

Discharge Piping

Discharge piping from the tank suction pump to the consolidation tanks will be DriscoPlex 3408 series HDPE piping for abrasion resistance. The pipe will be SDR-9.0 for pressures up to 200 psig. The pipe will be encased within a 4" DriscoPlex 4100 series HDPE pipe from the pump discharge to the consolidation tank skid. Piping within the consolidation skid will not be encased.

Encasement Pipe

Encasement pipe will run from the V-tanks area to the consolidation tanks containment pan. This encasement pipe will be 4" HDPE piping, SDR 21 or thicker.

The sludge transfer line and the supernate return line within the encasement pipe will be drained when not in use to prevent freezing. However, if these lines are not drained or cannot be drained for some reason, the encasement pipe will be heated somewhat to help prevent freezing of the lines within. This protection will be for outside temperatures down to 0 degrees F. It is assumed that the line will be drained at all times when the outside temperature is below 0 degrees F.

$$Q = UA(T_i - T_o)$$

$$U = 1/R = 0.333 \text{ BTU/(hr ft}^2\ {}^{o}\text{F)}$$

$$A = \pi\ D\ L = (\pi)\ (4.5/12 \text{ ft})\ (250 \text{ ft}) = 295 \text{ ft}^2$$

T_i = 42 degrees F (mean temperature of air within pipe)

T_o = 0 degrees F (minimum OAT for which freeze protection is required)

Q = (0.333 BTU/(hr ft^2 $^\circ$F)) (295 ft^2) (42 $^\circ$F – 0 $^\circ$F) = 4,126 BTU/hr

Determine the quantity of air required to flow through encasement at 52 $^\circ$F EAT and 32°F LAT.

Q = .93 CFM ΔT ➔ CFM = Q / (.93 ΔT)

CFM = (4,126 BTU/hr) / {(.93)(55°F – 32 $^\circ$F)}

CFM = 193 ft^3/min

V-TANKS VENTILATION REQUIREMENTS

Ventilation of the V-tanks is required to help reduce the release of VOC's and radioactive contaminants from the tanks during the contents removal operations. These operations will include moving sludge, mixing, spraying, and washing of the tanks with supernate and tank contents which may contain VOC's and radioactive contaminants.

The ventilation system is being designed and provided by others. This section in only to provide a recommended flow rate for ventilation of the tanks during contents removal.

Ventilation Criteria

Capture Velocity: 150 ft/min inward face velocity through any opening in the tank.

Anticipated Openings: It is anticipated that a manhole and one 6" diameter nozzle will be open at any time. Other openings will be plugged, capped, or taped.

Ventilation Calculations

$V = 125$ ft/min

$A_{MH} = (\pi)(d)^2/4 = (\pi)(20/12 \text{ ft})^2(1/4) = 2.18 \text{ ft}^2$

$A_{6"} = (\pi)(d)^2/4 = (\pi)(6/12 \text{ ft})^2(1/4) = 0.20 \text{ ft}^2$

$Q_{MH} = VA_{MH} = (125 \text{ ft/min})(2.18 \text{ ft}^2) = 273 \text{ ft}^3/\text{min}$

$Q_{6"} = VA_{6"} = (125 \text{ ft/min})(0.20 \text{ ft}^2) = 25 \text{ ft}^3/\text{min}$

$Q_{Total} = Q_{MH} + Q_{6"} = 273 \text{ ft}^3/\text{min} + 25 \text{ ft}^3/\text{min}$

➔ $\mathbf{Q_{Total} = 298 \text{ ft}^3/\text{min}}$

It is understood that polyethylene covers will be in place over the manholes during most of the spraying operations. The above flow rate will allow for the cover to be removed while still maintaining an appropriate capture velocity within the tanks. Once the openings are covered, the flow rate can be reduced.

Note: It has been found that velocities significantly lower or significantly higher that the target 125 ft/min actually create problems. Higher and lower velocities cause eddies at the entrance faces that pull contaminants from the containment. Some of the contaminants within the V-tanks will be lighter than air when disturbed. They will collect at the top of the tanks where they will escape if the capture velocities are not correct. Therefore, it is important that the face velocity at each opening be monitored closely by safety personnel to ensure that each velocity is acceptable.